

PATENT ABSTRACTS OF JAPAN

(11)Publication number : 10-010215
(43)Date of publication of application : 16.01.1998

(51)Int.Cl.

G01R 33/02
H01L 43/02

(21)Application number : 08-164197
(22)Date of filing : 25.06.1996

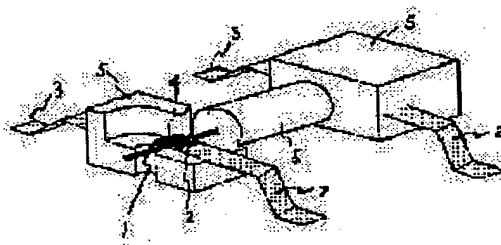
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(54) MAGNET IMPEDANCE EFFECT ELEMENT

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a magnetic impedance effect element which has a structure capable of easily connecting to external circuits such as a conducting circuit and a voltage detecting circuit, in other words, capable of circuit installation and is capable of easily forming a coil around a magnetic body.

SOLUTION: This impedance effect element changes voltage with time variation of magnetic flux in circumferential direction caused by impressing current varying with time to a magnetic body, by externally impressing magnetic field. In this case, the magnetic body 1 and conductive metal electrodes 2 connected to the magnetic body 1 are coated with resin 5 and terminals 2 for external connection connected with individual electrodes 2 are provided.



LEGAL STATUS

[Date of request for examination]

08.05.2003

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

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CLAIMS

[Claim(s)]

[Claim 1] The magnetic impedance effectiveness component characterized by coming to have the terminal for external connection which the electrode of the conductive metal connected to the magnetic substance and its magnetic substance was covered with resin, and became in the magnetic impedance effectiveness component to which the electrical potential difference to time-amount change of the magnetic flux of the hoop direction produced by impressing the current which changes in time to the magnetic substance changes by the external impression field, and was connected with each electrode.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the magnetic impedance effectiveness component useful as the magnetic head, various kinds of magnetic sensors, etc. used for the magnetic scale of a rotary encoder and a numerical-control device which are an audio tape recorder, a video tape recorder, a computer, and a measurement control equipment in more detail about the magnetic impedance effectiveness component.

[0002]

[Description of the Prior Art] Small high performance-ization of an AV equipment, a computer, a measurement control equipment, a numerical-control device, etc. is progressing quickly with development of a microelectronic technology. And in order to attain the miniaturization of each of these devices, it points to small high performance-ization also about the various magnetic sensors represented by the magnetic head. From such a background, the motion using a magnetic resistance element as the magnetic head was seen, and the miniaturization of a device has been pushed further. However, 20 gauss or more and since an external magnetic field small [a magnetic resistance element / as a maximum of 6% or less / very] the rate of change of electric resistance and required to produce several% of magnetic-reluctance change was large, the problem was in sensibility. Then, development of the magnetic cell which shows the sensibility superior to a magnetic resistance element is performed, and the magnetic impedance effectiveness component is proposed by JP, 7-181239, A as a new micro magnetic cell.

[0003]

[Problem(s) to be Solved by the Invention] The magnetic impedance effectiveness component proposed with the above-mentioned official report shows the example of circuit connection of the magnetic impedance effectiveness mold component based on the above-mentioned official report to drawing 4 which is the magnetic cell to which the electrical potential difference to time amount change of the periphery magnetic flux produced by impressing the alternating current of a RF to a magnetic line is changed by the external impression field. Among drawing 4, alternating current energizes the magnetic substance 1 from the source 8 of alternating current, and the electrical potential difference guided from the magnetic substance 1 is obtained as magnetic impedance effectiveness output voltage 12 from the electric-wire section to connect. Although fixed resistance 9, variable resistance 10, and an operational amplifier 11 are required for a circuit part as shown in drawing 1 when the alternating current to energize is the low frequency to which the skin effect does not occur in the magnetic substance, in high frequency current which the skin effect produces in the magnetic substance to energize, such fixed resistance 9, variable resistance 10, and an operational amplifier 11 are unnecessary. According to the above-mentioned official report, using for the magnetic substance 1 the amorphous magnetism line whose diameter is 30-124 micrometers and whose die length is 1-5.5mm is indicated.

[0004] However, in order that this invention persons may produce the magnetic cell using the magnetic impedance effectiveness component based on the indication of the above-mentioned official report If soldering performs assembly of a component using the amorphous magnetism line whose diameter is 30 micrometers and whose die length is 3mm The problem that connection between a magnetic line with a very thin diameter and external circuits, such as an energization circuit and an electrical-potential-difference detector, is difficult, and workability is bad, and it was

generated also when assembling does not take time amount or an external circuit and good connection occasionally are not obtained became clear. Moreover, in order to improve the property of the magnetic impedance effectiveness component, when a coil was wound around the perimeter of the magnetic substance, the amorphous magnetism line has been arranged in a glass capillary, the very complicated activity of rolling a coil on a glass tube had to be done, and there was also a problem that a coil could not be easily formed in the perimeter of the magnetic substance. This invention aims at offering the magnetic impedance effectiveness component which has easily the connectable structure in which the so-called circuit mounting is possible with external circuits, such as an energization circuit and an electrical-potential-difference detector, and can form a coil in the perimeter of the magnetic substance easily.

[0005]

[Means for Solving the Problem] In order that this invention persons may solve such a technical problem, the electrode section linked to the magnetic substance which is the basic structure of the magnetic impedance effectiveness component, and the magnetic substance is wholeheartedly covered with resin as a result of examination. By preparing the terminal for external connection connected with the electrode, a header and this invention were reached in the fact that the magnetic impedance effectiveness component which has the structure which can connect with external circuits, such as an energization circuit and an electrical-potential-difference detector, easily, and a coil can form in the perimeter of the magnetic substance easily is obtained. Namely, this invention is set for the magnetic impedance effectiveness component to which the electrical potential difference to time amount change of the magnetic flux of the hoop direction produced by impressing the current which changes in time to the magnetic substance is changed by the external impression field. Let the magnetic impedance effectiveness component characterized by coming to have the terminal for external connection which the electrode of the conductive metal connected to the magnetic substance and its magnetic substance was covered with resin, and became, and was connected with each electrode be a summary.

[0006]

[Embodiment of the Invention] Hereafter, this invention is explained concretely, referring to a drawing. The magnetic impedance effectiveness component in this invention makes the electrical potential difference produced by impressing the current which changes in time to the magnetic substance output outside according to the magnitude of an impression field, and realizes the small magnetic cell which shows the sensibility excellent in easy structure. Drawing 1 is the perspective view showing an example of the magnetic impedance effectiveness component of this invention. As shown in drawing 1, the electrode 2 which consists of a conductive metal is connected to the magnetic substance 1, and both are further covered with resin 5. And the terminal 2 (some conductive metals which constitute an electrode 2 in this case serve as the terminal for external connection) for external connection connected with each electrode 2 has composition which came out to the outside of covering resin. Moreover, the magnetic impedance effectiveness component of this invention may be equipped with the terminal 3 for coils if needed.

[0007] It is desirable that the permeability in 5mOe and a 1kHz excitation field is 1000 or more high permeability metallic materials as the magnetic substance 1 used for this invention, and the crystal structure (a crystalline substance and amorphous substance) of the magnetic substance, an alloy presentation, or especially a configuration is not limited. For example, the thin line which consists of high permeability amorphous metals in which the magnetic impedance effectiveness is accepted notably as the magnetic substance 1 used for this invention, a thin band, and a thin film can be used, and in it, since anything of the configuration of a thin line, a thin band, and a thin film is easily obtained as 10000 or more high permeability materials, especially as the magnetic substance 1 of this invention, it is desirable [the amorphous metals which use Co-Fe-Si-B as a principal component the permeability in 5mOe and a 1kHz excitation field].

[0008] In this invention, it is required to connect the electrode 2 which becomes the magnetic substance 1 from a conductive metal, and it says that the connection as used in the field of this invention is connected so that the magnetic substance 1 and an electrode 2 can take ohmic contact. As both connection method, connection by the pewter 4 as shown in drawing 1, and various approaches, such as a resistance welding method, are used. As a conductive metal which constitutes the electrode 2 in this invention, although metals or those alloys, such as copper, aluminum, iron, and

nickel, can be used, it is desirable to use the lead frame material which consists of a copper alloy or an iron alloy also in it.

[0009] In addition, the conductive ingredient by which that out of which some conductive metals which constitute an electrode 2 as a terminal 2 for external connection as shown in drawing 2 have come to the outside of covering resin was also connected with the electrode 2 may come out to the outside of covering resin. By having this terminal 2 for external connection, connection between external circuits, such as an energization circuit and an electric detector, and the component of this invention can be made easily and good, and the magnetic impedance effectiveness component in which circuit mounting is possible is realized. And an energization current can be impressed to the magnetic substance 1 which constitutes the magnetic impedance effectiveness component of this invention by this, or it can perform now easily outputting outside the electrical potential difference generated from the magnetic substance 1.

[0010] Furthermore, in this invention, it is required to cover with resin 5 the electrode 2 of the conductive metal connected to the magnetic substance 1 and its magnetic substance. Although the thing of various synthetic macromolecules excellent in electric insulation can be used as resin 5 used for this invention and various thermosetting resin or thermoplastics can be used, injection molding is possible especially, and it is ASTM. The resin whose heat deflection temperature by D648 (18.6kg/cm²) is 150 degrees C or more is desirable, and it is still more desirable for heat deflection temperature to be 200 degrees C or more. Moreover, the resin containing inorganic substance fiber and inorganic substance particles, such as glass and an oxide, can also be used. As resin 5 used for this invention, polyarylate, polyethylene terephthalate, liquid crystal polyester, a polyamide, polyimide, etc. are raised, for example.

[0011] Moreover, as for the enveloping layer of the resin 5 in this invention, it is desirable to have the part of the bobbin configuration which covers some or all of the magnetic substance 1 with the thickness of 0.1–5mm around the magnetic substance 1. In this invention, by covering the perimeter of the magnetic substance 1 with the resin of a bobbin configuration, a coil can be twisted around the part of this bobbin configuration, and the magnetic impedance effectiveness component which has a desired property can be realized. Thus, when taking the configuration which has arranged the design top coil of a component around the magnetic substance, it is desirable to have the terminal 3 for coils which consists of a conductive ingredient as shown in drawing 1. Moreover, when resin is covered by the electrode section connected to the magnetic substance, even if a component is put to the bottom of an elevated temperature and a pewter is in a melting condition, the breadth of a pewter is regulated with the resin which has covered the electrode section. Moreover, even if it is under the intense heat environment of a temperature gradient, always good electrical connection can be planned.

[0012] After connecting the magnetic substance and an electrode by soldering etc. using the magnetic substance which has a desired property and a desired configuration, the magnetic impedance effectiveness component of this invention prepares the terminal for coils the terminal for external connection linked to an electrode, and if needed, and is manufactured by covering the magnetic substance and an electrode with resin using an injection-molding technique etc. Therefore, the magnetic impedance effectiveness component of this invention can be manufactured combining various electrode junction techniques, or resin covering and forming technique. In addition, after making pewter connection of the magnetic substance on a leadframe using a conductive good leadframe metallic material as an electrode, the terminal for external connection, and a terminal for coils, the approach of using metal mold and covering resin with injection molding is especially desirable as the manufacture approach of the magnetic impedance effectiveness component of this invention.

[0013]

[Example] Next, an example explains this invention concretely.

As the example 1 magnetic substance 1, the diameter in which the alloy presentation passed through the cold drawing process from quenching material by 72.5(Co0.94Fe0.06) Si 12.5B15 (a figure expresses atomic %) used the amorphous magnetism thin line which performed heat treatment for the amorphous magnetism thin line which is 30 micrometers for 15 seconds under the temperature of 475 more degrees C. Moreover, the leadframe with a thickness of 0.5mm which used brass as the parent, performed coppering to the substrate and performed pewter plating to the upper layer was used for

the electrode 2 (it serves as the terminal 2 for external connection) and the terminal 3 for coils which serve as the terminal for external connection. Inter-electrode distance was set to 3mm here. The electrode section linked to the magnetic substance 1 has 0.5mm long and a 1.0mm wide rectangle, and connection between an amorphous magnetism thin line and an electrode 2 was made using the pewter 4 (KR-19, product made from Japanese ARUMITTO). Install the leadframe which connected the amorphous magnetism thin line in the predetermined location of shaping metal mold, and subsequently, by injecting the fused resin at about 300 degrees C to metal mold Cover an amorphous magnetism thin line, an electrode 2 (it serves as the terminal 2 for external connection), the electrode connection (pewter) 4, and some terminals 3 for coils with resin 5, and it is made for the terminal 2 for external connection and the terminal 3 for coils to come out to the outside of covering resin 5. The magnetic impedance effectiveness component of this invention as shown in drawing 1 was produced. In addition, the shaping metal mold produced so that the enveloping layer by the resin of the periphery of an amorphous magnetism thin line might become a bobbin configuration with a thickness of 5mm was used, using liquid crystal polyester (rod run LC5000 series, Unitika, Ltd. make) as resin 5.

[0014] Next, the produced magnetic impedance effectiveness component has been arranged in a solenoid coil with a bore of 5cm, and the frequency of 100kHz and alternating current of 5mA of currents were impressed to the magnetic impedance effectiveness component in the same circuitry as drawing 4. And the solenoid coil was made to generate amplitude 5Oe and a triangular wave with a frequency of 60Hz, the external magnetic field was applied to the magnetic impedance effectiveness component, and the electrical potential difference after canceling a part for the electric resistance in the magnetic substance from the electrical potential difference generated from the magnetic substance 1 was measured as magnetic impedance effectiveness output voltage 12. In addition, the circuit shown in drawing 4 used here consists of operational amplifiers 11 of the source 8 of alternating current of 5mA of alternating current with a frequency of 100kHz, the variable resistance 10 of 9,100 ohms of fixed resistance of 10kohm, and LC6361 system. The measured result is shown in drawing 2. The axis of abscissa of drawing 2 shows an external magnetic field (Oe), and an axis of ordinate shows the magnetic impedance effectiveness output voltage (mV). It is clearer than drawing 2 that the magnetic impedance effectiveness component's of this invention the sensibility which was excellent to field change is shown. Moreover, although the property of the magnetic impedance effectiveness component before covering with resin was also collectively shown in drawing 2, it was checked that the same outstanding magnetic impedance effectiveness as the case where the magnetic impedance effectiveness component of this invention does not perform resin covering is shown.

[0015] Furthermore, with the magnetic impedance effectiveness component of this invention produced by the aforementioned approach, using the enveloping layer (part of a bobbin configuration) of the resin formed in the perimeter of an amorphous magnetism thin line, a coil is possible, and as shown in drawing 3, the coil using the urethane covering copper wire 6 of the diameter of 0.1mm was able to be formed easily. In addition, the copper-wire edge 7 is twisted around the terminal 3 for coils, and is connected to a terminal 3 by the pewter here. Moreover, since it has the terminal for coils the terminal for external connection, and if needed, the magnetic impedance effectiveness component by this invention can connect easily the terminal for external connection, and the terminal for coils to the various land parts of a circuit base, and on various circuit bases, the pewter reflow method etc. is used and it can be mounted easily.

[0016]

[Effect of the Invention] It can connect with external circuits, such as an energization circuit and an electrical-potential-difference detector, easily, and the magnetic impedance effectiveness component of this invention becomes possible [mounting in electronic parts easily]. Moreover, a coil can form in the perimeter of the magnetic substance easily, and the magnetic impedance effectiveness component which has the outstanding property is obtained. Therefore, to the specification of the magnetic sensor used for various applications, the magnetic impedance effectiveness component with a desired property can be realized easily, and a magnetic impedance component with very high application and versatility can be offered as a magnetic cell.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the perspective view showing an example of the magnetic impedance effectiveness component of this invention.

[Drawing 2] It is the property Fig. showing the magnetic impedance output voltage to an external magnetic field.

[Drawing 3] It is the schematic diagram showing an example of a component which gave the coil coil to the magnetic impedance effectiveness component of this invention.

[Drawing 4] It is drawing showing the circuit for carrying out energization and electrical-potential-difference detection to the magnetic impedance effectiveness component.

[Description of Notations]

- 1 Magnetic Substance
- 2 Electrode, Terminal for External Connection
- 3 Terminal for Coils
- 4 Pewter
- 5 Resin
- 6 Copper Wire
- 7 Copper-Wire Edge
- 8 Source of Alternating Current
- 9 Fixed Resistance
- 10 Variable Resistance
- 11 Operational Amplifier
- 12 The Magnetic Impedance Effectiveness Output Voltage

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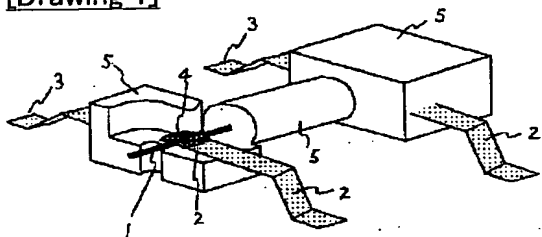
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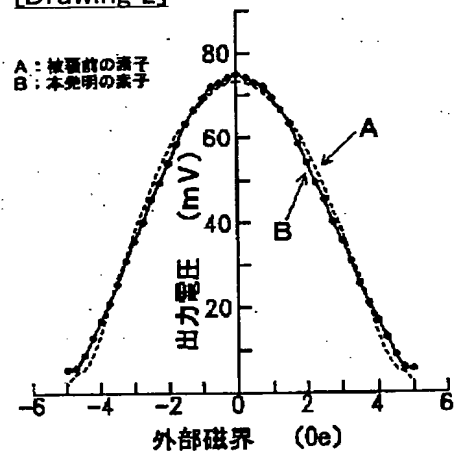
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DRAWINGS

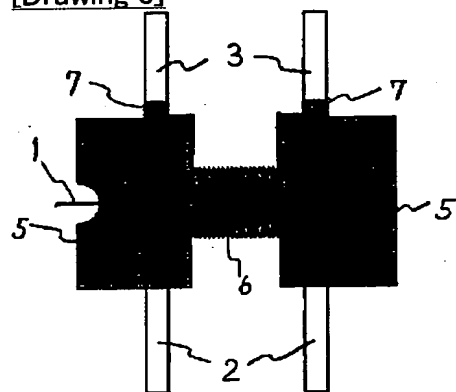
[Drawing 1]



[Drawing 2]

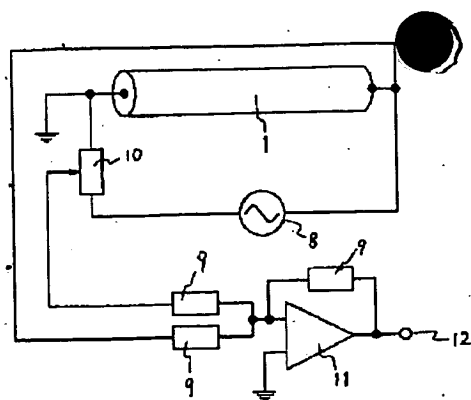


[Drawing 3]



[Drawing 4]





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(19)日本国特許庁 (J P)

(12) 公開特許公報 (A)

(11)特許出願公開番号

特開平10-10215

(43)公開日 平成10年(1998)1月16日

(51)Int.Cl.⁸

識別記号

庁内整理番号

F I

技術表示箇所

G 0 1 R 33/02

G 0 1 R 33/02

D

H 0 1 L 43/02

H 0 1 L 43/02

Z

審査請求 未請求 請求項の数 1 O L (全 5 頁)

(21)出願番号 特願平8-164197

(22)出願日 平成8年(1996)6月25日

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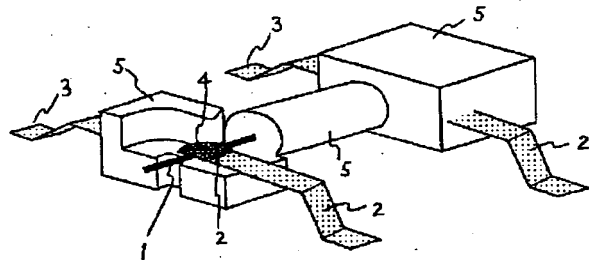
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(54)【発明の名称】 磁気インピーダンス効果素子

(57)【要約】

【課題】 通電回路や電圧検出回路等の外部回路と容易に接続が可能な、いわゆる回路実装可能な構造を有し、かつコイルを磁性体の周囲に容易に形成できるような磁気インピーダンス効果素子を提供する。

【解決手段】 時間的に変化する電流を磁性体に印加することによって生じる周方向の磁束の時間変化に対する電圧を、外部印加磁界によって変化させる磁気インピーダンス効果素子において、磁性体1とその磁性体1に接続された導電性金属の電極2とが樹脂5により被覆されてなり、かつ、それぞれの電極2と接続された外部接続用端子2を備えてなることを特徴とする磁気インピーダンス効果素子。



【特許請求の範囲】

【請求項1】 時間的に変化する電流を磁性体に印加することによって生じる周方向の磁束の時間変化に対する電圧を、外部印加磁界によって変化させる磁気インピーダンス効果素子において、磁性体とその磁性体に接続された導電性金属の電極とが樹脂により被覆されてなり、かつ、それぞれの電極と接続された外部接続用端子を備えてなることを特徴とする磁気インピーダンス効果素子。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、磁気インピーダンス効果素子に関するものであり、さらに詳しくは、オーディオテープレコーダ、ビデオテープレコーダ、コンピュータ、計測制御機器であるロータリエンコーダ、数値制御機器の磁気スケールなどに用いられている磁気ヘッドや各種の磁気センサー等として有用な磁気インピーダンス効果素子に関するものである。

【0002】

【従来の技術】マイクロエレクトロニクス技術の発展にともなう、AV機器、コンピュータ、計測制御機器、数値制御機器等の小型高性能化が急速に進んでいる。そして、これらの各機器の小型化を達成するために、磁気ヘッドに代表される各種磁気センサーについても小型高性能化が指向されるようになってきている。このような背景から、磁気抵抗素子を磁気ヘッドとして用いる動きが見られるようになっており、機器の小型化が一層押し進められてきた。しかし、磁気抵抗素子は電気抵抗の変化率が最大6%以下と非常に小さく、数%の磁気抵抗変化を生じさせるのに必要な外部磁界は20 Gauss以上と大きい感度度の問題があった。そこで、磁気抵抗素子より優れた感度を示す磁気素子の開発が行われ、特開平7-181239号公報により新しいマイクロ磁気素子として磁気インピーダンス効果素子が提案されている。

【0003】

【発明が解決しようとする課題】上記公報により提案されている磁気インピーダンス効果素子は、高周波の交流電流を磁性線に印加することによって生じる円周磁束の時間変化に対する電圧を、外部印加磁界によって変化させる磁気素子である。図4に上記公報に基づく磁気インピーダンス効果型素子の回路接続例を示す。図4中、磁性体1は交流電流源8より交流電流が通電され、磁性体1より誘導された電圧は接続する電線部より磁気インピーダンス効果出力電圧12として得られる。通電する交流電流が磁性体に表皮効果が起きない低周波の場合は図1に示す様な回路部分に固定抵抗9、可変抵抗10及びオペアンプ11が必要であるが、通電する磁性体に表皮効果が生じるような高周波電流ではこれらの固定抵抗9、可変抵抗10及びオペアンプ11は不要である。上記公報によれば、磁性体1には直径が30~124μ

m、長さが1~5.5mmの非晶質磁性線を用いることが記載されている。

【0004】しかし、本発明者らが、上記公報の開示に基づき、磁気インピーダンス効果素子を用いた磁気素子を作製するために、直径が30μm、長さが3mmの非晶質磁性線を用いてハンダ付けにより素子の組立を行うと、直径が非常に細い磁性線と通電回路や電圧検出回路等の外部回路との接続が困難で作業性が悪く、組立に時間がかかったり、時には外部回路と良好な接続が得られない場合も生じるという問題が明らかになった。また、磁気インピーダンス効果素子の特性を改善するためにコイルを磁性体の周囲に巻く場合、非晶質磁性線をガラス細管中に配置し、ガラス管上にコイルを巻くという非常に煩雑な作業を行わなければならない、コイルを容易に磁性体の周囲に形成できないという問題もあった。本発明は、通電回路や電圧検出回路等の外部回路と容易に接続が可能な、いわゆる回路実装可能な構造を有し、かつコイルを磁性体の周囲に容易に形成できるような磁気インピーダンス効果素子を提供することを目的とするものである。

【0005】

【課題を解決するための手段】本発明者らは、このような課題を解決するために鋭意検討の結果、磁気インピーダンス効果素子の基本構造である磁性体と磁性体に接続する電極部分とを樹脂により被覆し、電極と接続された外部接続用端子を設けることにより、通電回路や電圧検出回路等の外部回路と容易に接続が可能であり、かつ、磁性体の周囲にコイルが容易に形成できる構造を有する磁気インピーダンス効果素子が得られるという事実を見出し、本発明に到達した。すなわち、本発明は、時間的に変化する電流を磁性体に印加することによって生じる周方向の磁束の時間変化に対する電圧を、外部印加磁界によって変化させる磁気インピーダンス効果素子において、磁性体とその磁性体に接続された導電性金属の電極とが樹脂により被覆されてなり、かつ、それぞれの電極と接続した外部接続用端子を備えてなることを特徴とする磁気インピーダンス効果素子を要旨とするものである。

【0006】

【発明の実施の形態】以下、図面を参照しつつ本発明を具体的に説明する。本発明における磁気インピーダンス効果素子は、時間的に変化する電流を磁性体に印加することによって生じる電圧を、印加磁界の大きさに応じて外部に出力させるものであり、簡単な構造で優れた感度を示す小型磁気素子を実現するものである。図1は、本発明の磁気インピーダンス効果素子の一例を示す斜視図である。図1に示すように、磁性体1に導電性金属からなる電極2が接続されており、さらに、両者が樹脂5で被覆されている。そして、それぞれの電極2と接続された外部接続用端子2（この場合、電極2を構成する導電

性金属の一部が外部接続用端子を兼ねている)が被覆樹脂の外側に出た構成になっている。また、本発明の磁気インピーダンス効果素子は、必要に応じてコイル用端子3を備えていてもよい。

【0007】本発明に用いられる磁性体1としては、5 mOe、1 kHzの励振磁界における透磁率が1000以上の高透磁率金属材料であることが好ましく、磁性体の結晶構造(結晶質・非晶質)、合金組成又は形状は特に限定されるものではない。例えば、本発明に用いられる磁性体1として、磁気インピーダンス効果が顕著に認められる高透磁率非晶質金属材料からなる細線、薄帯、薄膜を用いることができ、その中でも、Co-Fe-Si-Bを主成分とする非晶質金属材料は、5 mOe、1 kHzの励振磁界における透磁率が10000以上の高透磁率材料として細線、薄帯、薄膜のいずれの形状のものでも容易に得られることから、本発明の磁性体1としては特に好ましい。

【0008】本発明においては、磁性体1に導電性金属からなる電極2が接続されていることが必要であり、本発明でいう接続とは、磁性体1と電極2とがオーミックコンタクトがとれるように接続されていることをいう。両者の接続方法としては、図1に示すようなハンダ4による接続や、抵抗溶接法等、種々の方法が用いられる。本発明における電極2を構成する導電性金属としては、銅、アルミニウム、鉄、ニッケル等の金属あるいはそれらの合金を用いることができるが、その中でも銅合金や鉄合金からなるリードフレーム材料を用いることが望ましい。

【0009】なお、外部接続用端子2としては、図2に示すように電極2を構成する導電性金属の一部が被覆樹脂の外側に出ているものでも、電極2と接続された導電性材料が被覆樹脂の外側に出ているものでもよい。この外部接続用端子2を備えることにより、通電回路や電気検出回路等の外部回路と本発明の素子との接続を容易にかつ良好に行うことができ、回路実装可能な磁気インピーダンス効果素子が実現される。そして、これにより、本発明の磁気インピーダンス効果素子を構成する磁性体1に通電電流を印加したり、磁性体1から発生する電圧を外部に出力することが容易に行えるようになる。

【0010】さらに、本発明においては、磁性体1とその磁性体に接続された導電性金属の電極2とが樹脂5により被覆されていることが必要である。本発明に用いられる樹脂5としては、電気絶縁性に優れた種々の合成高分子のものを用いることができ、種々の熱硬化性樹脂又は熱可塑性樹脂が利用できるが、中でも射出成形が可能で、ASTM D648(18.6 kg/cm²)による熱変形温度が150℃以上である樹脂が好ましく、熱変形温度が200℃以上であることがさらに望ましい。また、ガラスや酸化物などの無機物繊維や無機物粒子を含む樹脂を用いることもできる。本発明に用いられる樹

脂5としては、例えば、ポリアリレート、ポリエチレンテレフタレート、液晶ポリエステル、ポリアミド、ポリイミド等があげられる。

【0011】また、本発明における樹脂5の被覆層は、磁性体1の周囲に0.1~5 mmの厚さで磁性体1の一部もしくは全部を被覆するボビン形状の部分有していることが好ましい。本発明においては、磁性体1の周囲をボビン形状の樹脂で被覆することにより、このボビン形状の部分にコイルを巻き付けることができ、所望の特性を有する磁気インピーダンス効果素子を実現することができる。このように、素子の設計上コイルを磁性体の周囲に配置した構成をとる場合には、図1に示すごとく導電性材料からなるコイル用端子3を備えることが望ましい。また、磁性体に接続された電極部分にも樹脂が被覆されていることにより、素子が高温下に曝され、かつハンダが溶融状態であっても、電極部分を覆っている樹脂によりハンダの広がり規制される。また、温度差の激しい熱環境下であっても、常に良好な電気接続が図れる。

【0012】本発明の磁気インピーダンス効果素子は、所望の特性と形状を有する磁性体を用いて、磁性体と電極とをハンダ付けなどにより接続した後、電極と接続した外部接続用端子と、必要に応じてコイル用端子を設け、射出成形技術などを利用して磁性体と電極とを樹脂で被覆することにより製造される。したがって、本発明の磁気インピーダンス効果素子は、種々の電極接合技術や樹脂被覆・成形技術を組み合わせて製造することができる。なお、電極、外部接続用端子、コイル用端子として導電性の良好なリードフレーム金属材料を用い、磁性体をリードフレーム上にハンダ接続した後に、金型を用いて樹脂を射出成形により被覆する方法は、本発明の磁気インピーダンス効果素子の製造方法として特に好ましいものである。

【0013】

【実施例】次に、本発明を実施例によって具体的に説明する。

実施例1

磁性体1としては、合金組成が(Co_{0.94} Fe_{0.06})_{72.5} Si_{12.5} B₁₅(数字は原子%を表す)で急冷材から冷間線引き工程を経た直径が30 μmの非晶質磁性細線をさらに475℃の温度下で15秒間熱処理を施した非晶質磁性細線を使用した。また、外部接続用端子を兼ねる電極2(外部接続用端子2を兼ねる)とコイル用端子3には、真鍮を母体とし下地に銅メッキを上層にハンダメッキを施した厚さ0.5 mmのリードフレームを用いた。ここで電極間距離は3 mmとした。磁性体1と接続する電極部分は、縦0.5 mm、横1.0 mmの長方形になっており、非晶質磁性細線と電極2との接続はハンダ4(KR-19、日本アルミット社製)を用いて行った。次いで、非晶質磁性細線を接続したリードフレーム

を成形金型の所定場所に設置し、溶融した樹脂を金型に約300℃で射出することにより、非晶質磁性細線、電極2（外部接続用端子2を兼ねる）、電極接続部（ハンダ）4及びコイル用端子3の一部を樹脂5で被覆し、外部接続用端子2とコイル用端子3が被覆樹脂5の外側に出るようにして、図1に示すような本発明の磁気インピーダンス効果素子を作製した。なお、樹脂5としては、液晶ポリエステル（ロッドランLC5000シリーズ、ユニチカ社製）を用い、非晶質磁性細線の周辺部の樹脂による被覆層が厚さ5mmのボビン形状になるように作製された成形金型を用いた。

【0014】次に、作製した磁気インピーダンス効果素子を、内径5cmのソレノイドコイル中に配置し、図4と同様の回路構成にて周波数100kHz、電流5mAの交流電流を磁気インピーダンス効果素子に印加した。そして、ソレノイドコイルに振幅50e、周波数60Hzの三角波を発生させて磁気インピーダンス効果素子に外部磁界をかけ、磁性体1より発生する電圧から磁性体内の電気抵抗分をキャンセルした後の電圧を、磁気インピーダンス効果出力電圧12として測定した。なお、ここで用いられた図4に示す回路は、周波数100kHzの交流電流5mAの交流電流源8、10kΩの固定抵抗9、100Ωの可変抵抗10及びLC6361系のオペアンプ11から構成されている。測定された結果を図2に示す。図2の横軸は外部磁界（0e）を、縦軸は磁気インピーダンス効果出力電圧（mV）を示す。図2より、本発明の磁気インピーダンス効果素子は磁界変化に対し優れた感度を示すことが明らかである。また、図2には樹脂で被覆する前の磁気インピーダンス効果素子の特性も併せて示しているが、本発明の磁気インピーダンス効果素子は樹脂被覆を行わない場合と同様の優れた磁気インピーダンス効果を示すことが確認された。

【0015】さらに、前記の方法で作製した本発明の磁気インピーダンス効果素子では、非晶質磁性細線の周囲に形成された樹脂の被覆層（ボビン形状の部分）を利用して巻線が可能であり、図3に示すごとく、0.1mm径のウレタン被覆銅線6を用いたコイルを容易に形成することができた。なお、ここで銅線端部7はコイル用端子3に巻き付けられて、ハンダにより端子3に接続され

る。また、本発明による磁気インピーダンス効果素子は、外部接続用端子や必要に応じてコイル用端子が備えられていることから、回路基盤の各種ランド部分に外部接続用端子やコイル用端子を容易に接続することが可能であり、種々の回路基盤上にハンダリフロー法等を用いて容易に実装することが可能であった。

【0016】

【発明の効果】本発明の磁気インピーダンス効果素子は、通電回路や電圧検出回路等の外部回路と容易に接続が可能であり、電子部品に容易に実装することが可能となる。また、磁性体の周囲にコイルが容易に形成でき、優れた特性を有する磁気インピーダンス効果素子が得られる。したがって、種々の用途に用いられる磁気センサーの仕様に対し、所望の特性を有した磁気インピーダンス効果素子が容易に実現でき、磁気素子として非常に応用性・汎用性の高い磁気インピーダンス素子が提供できる。

【図面の簡単な説明】

【図1】本発明の磁気インピーダンス効果素子の一例を示す斜視図である。

【図2】外部磁界に対する磁気インピーダンス出力電圧を示す特性図である。

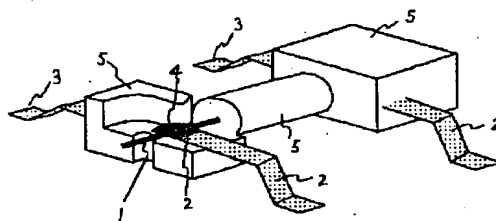
【図3】本発明の磁気インピーダンス効果素子にコイル巻線を施した素子の一例を示す概略図である。

【図4】磁気インピーダンス効果素子に通電、電圧検出をするための回路を示す図である。

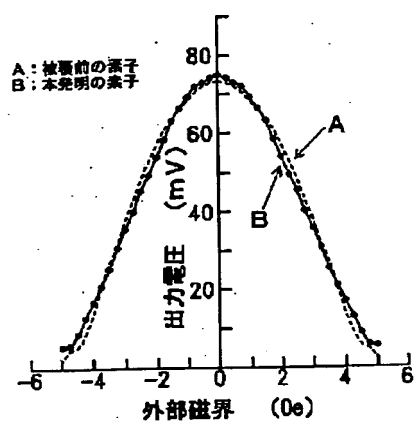
【符号の説明】

- 1 磁性体
- 2 電極、外部接続用端子
- 3 コイル用端子
- 4 ハンダ
- 5 樹脂
- 6 銅線
- 7 銅線端部
- 8 交流電流源
- 9 固定抵抗
- 10 可変抵抗
- 11 オペアンプ
- 12 磁気インピーダンス効果出力電圧

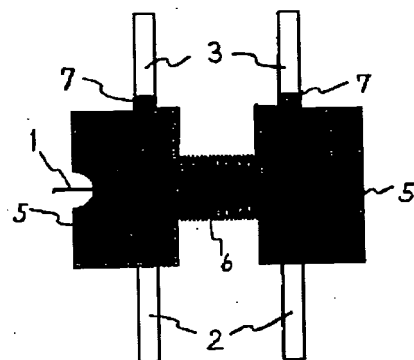
【図1】



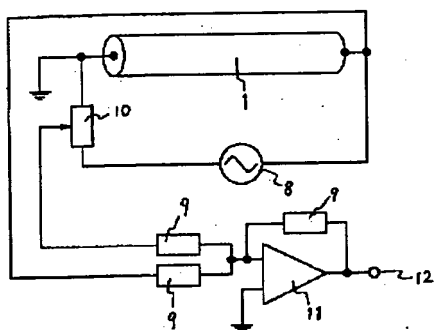
【図2】



【図3】



【図4】



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